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Powell et al.

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(54) **FREE-STATE SEAL PLATE FUNCTIONAL GAGE TOOL**

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(51) **Int. Cl.**

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G01M 15/14	(2006.01)
F02C 7/28	(2006.01)
B23Q 17/20	(2006.01)
F01D 25/28	(2006.01)

(52) **U.S. Cl.**

CPC ***G01M 15/14*** (2013.01); ***B23Q 17/20*** (2013.01); ***F01D 25/285*** (2013.01); ***F02C 7/28*** (2013.01); *F05D 2260/83* (2013.01); *Y10T 29/49771* (2015.01); *Y10T 29/49776* (2015.01)

(58) **Field of Classification Search**

CPC F01D 25/285; F02C 7/28; F05D 2260/83; G01M 15/14; Y10T 29/49771; Y10T 29/49776; B23Q 17/20

See application file for complete search history.

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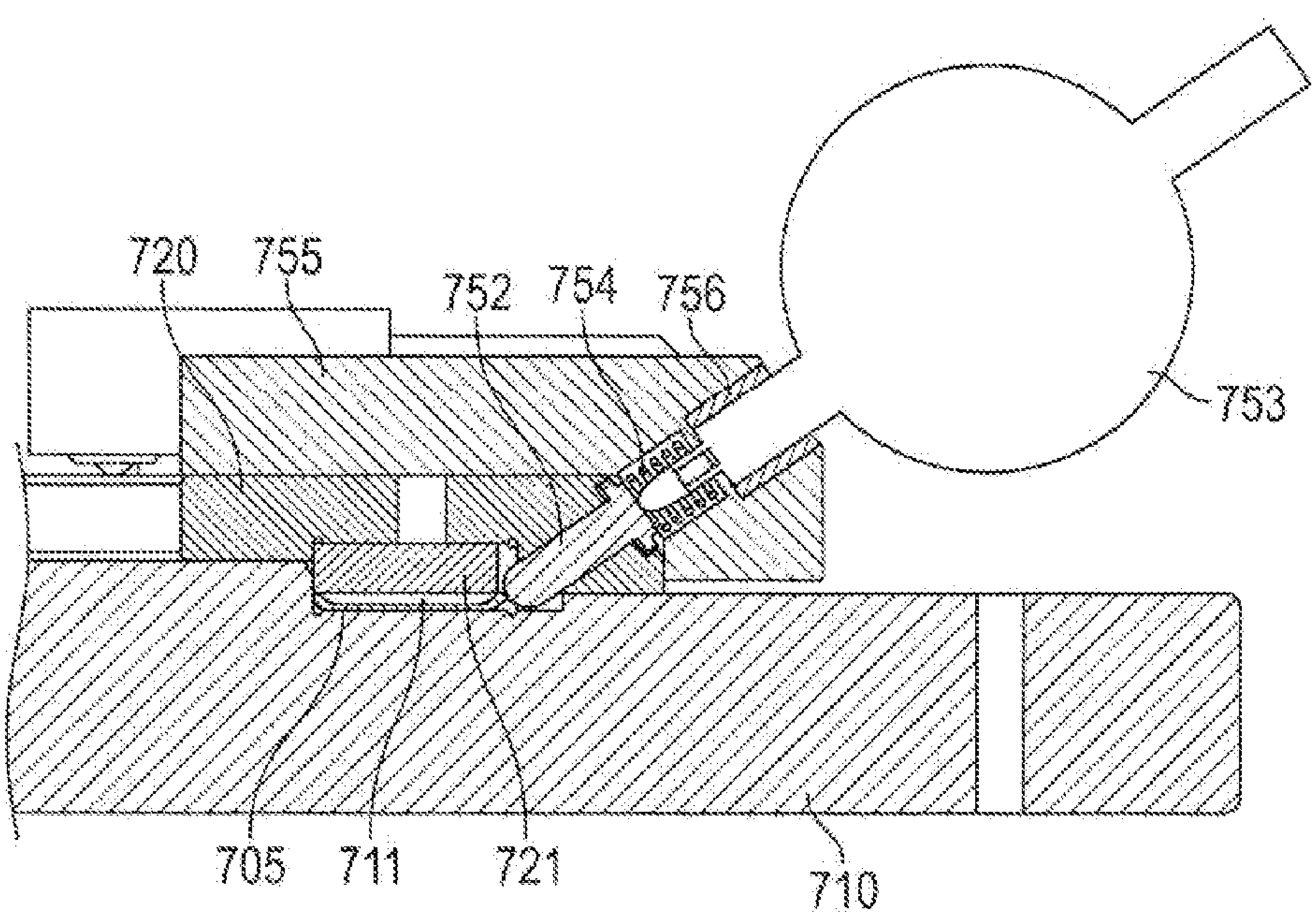
(57) **ABSTRACT**

A gage tool (**700**) for inspecting tolerances of a gas turbine engine seal plate (**430**) includes a base plate (**710**) and a top plate (**720**). The base plate (**710**) includes a base opening (**712**) and a slot (**711**) with an annular shape sized to receive a seal plate (**430**). The top plate (**720**) includes a top opening (**723**). The base opening (**712**) and top opening (**723**) each provide access to a portion of a seal plate (**430**) within the gage tool (**700**). The gage tool (**700**) also includes a first gage (**750**) with a probe tip for measuring a variation in an outer interlacing surface (**433**) of a seal plate (**430**) and a seal slide gage (**740**) for measuring a force required to rotate the seal plate (**430**) within the gage tool.

15 Claims, 6 Drawing Sheets



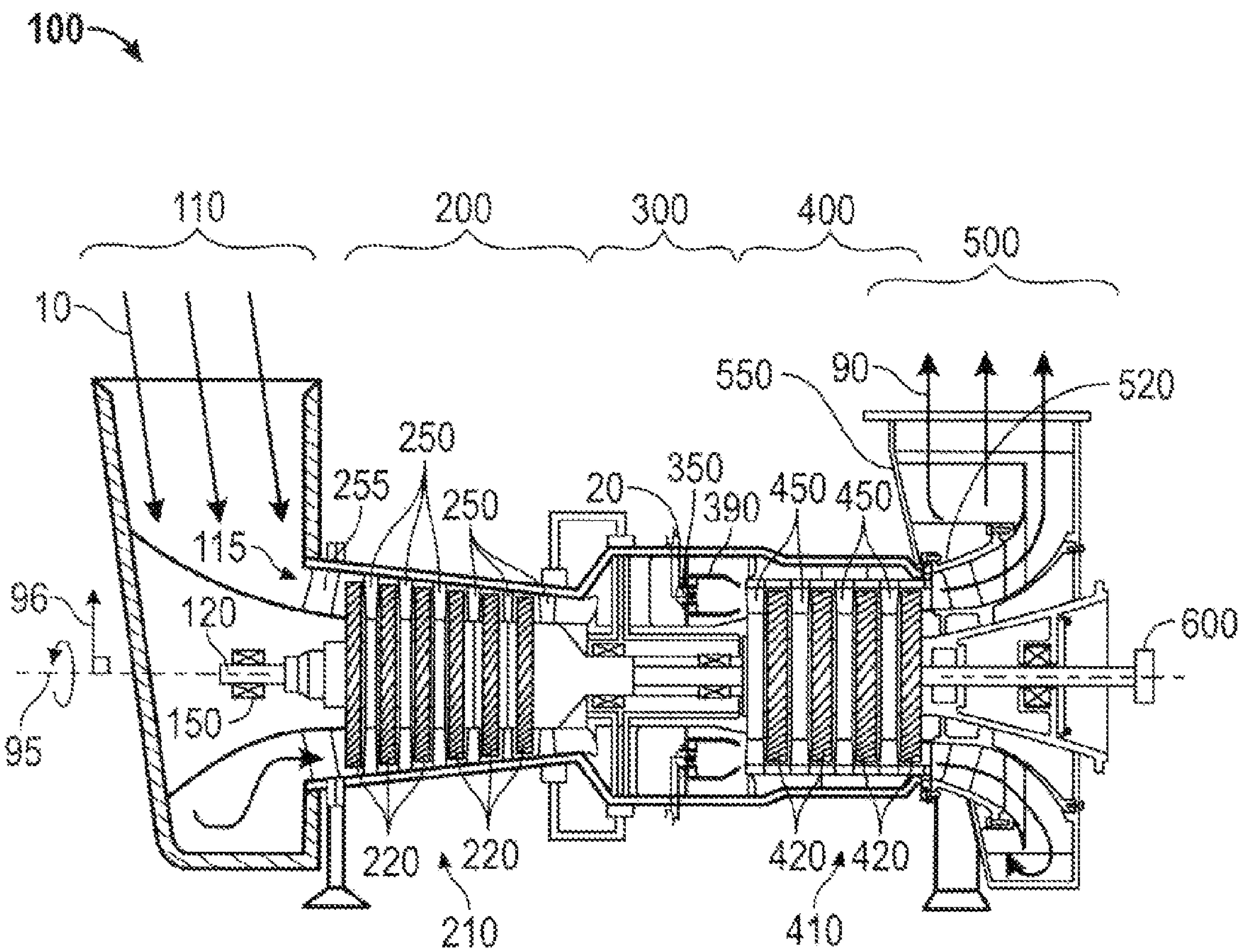

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FIG. 1

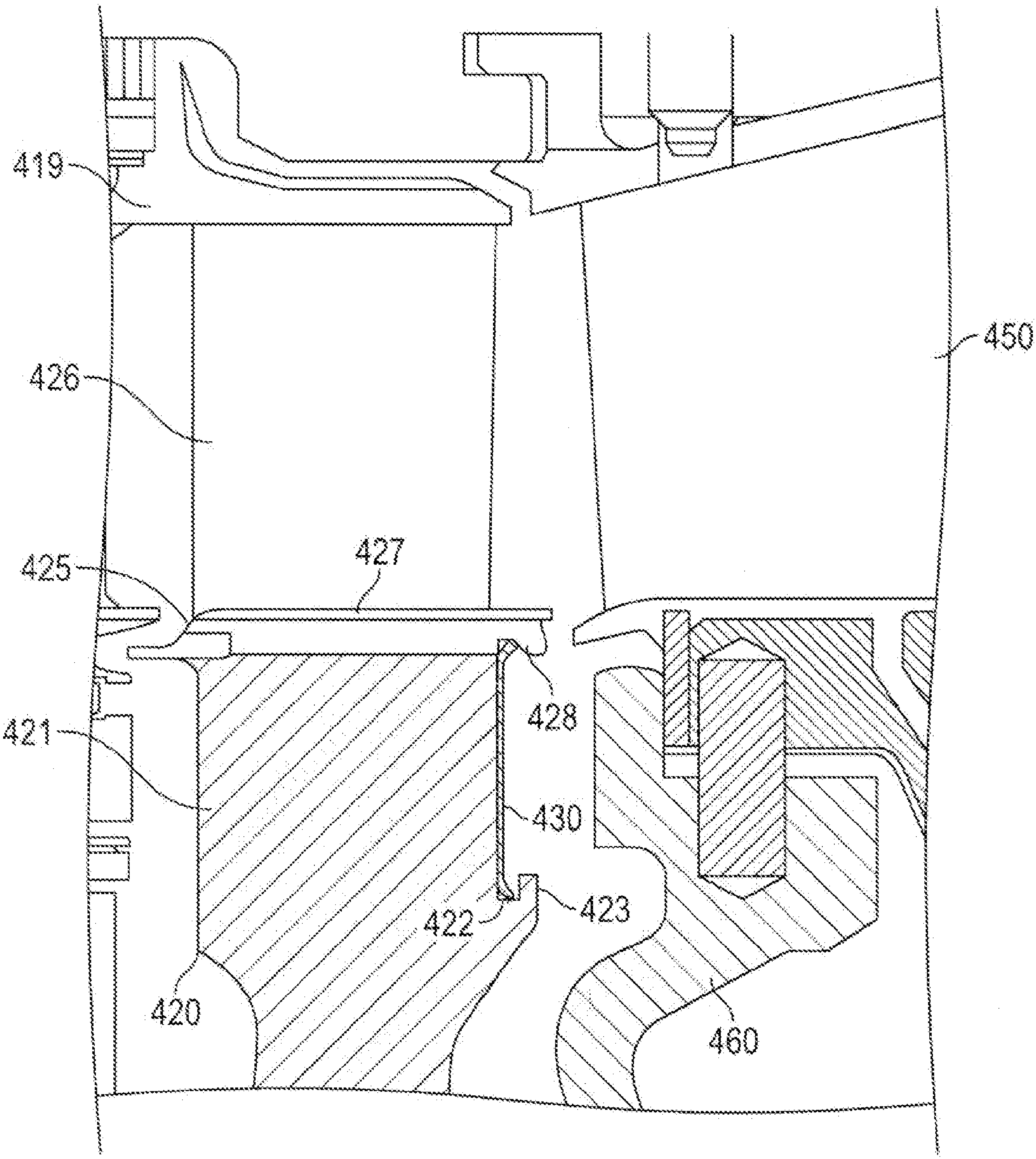


FIG. 2

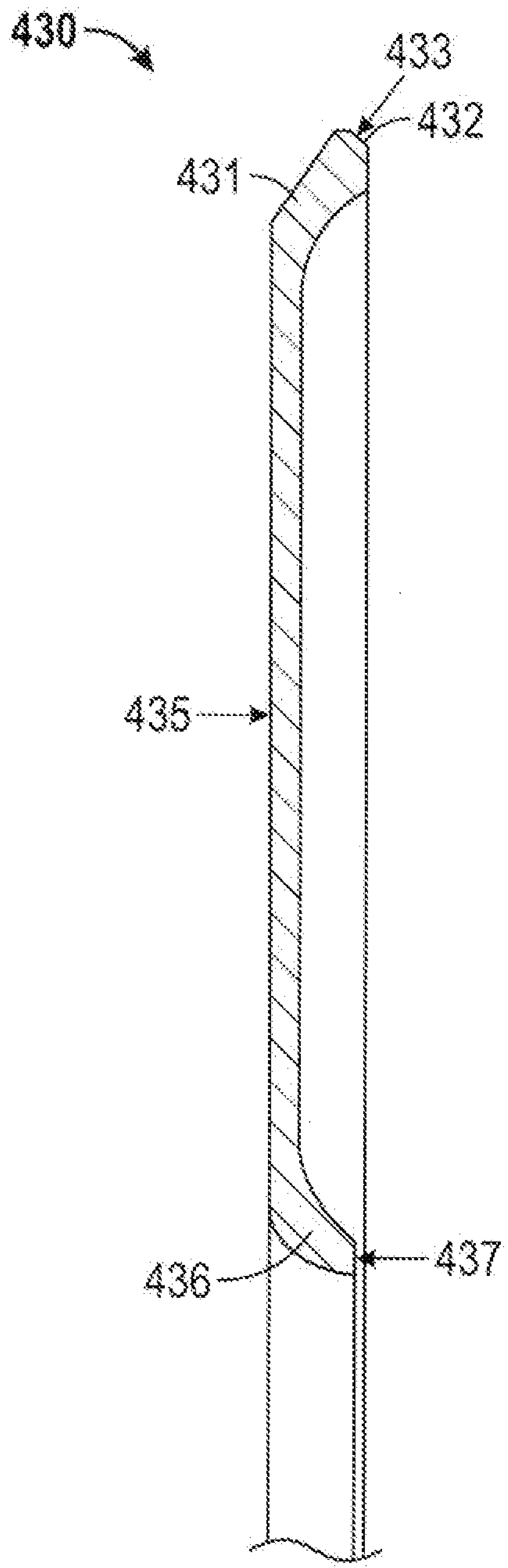


FIG. 3

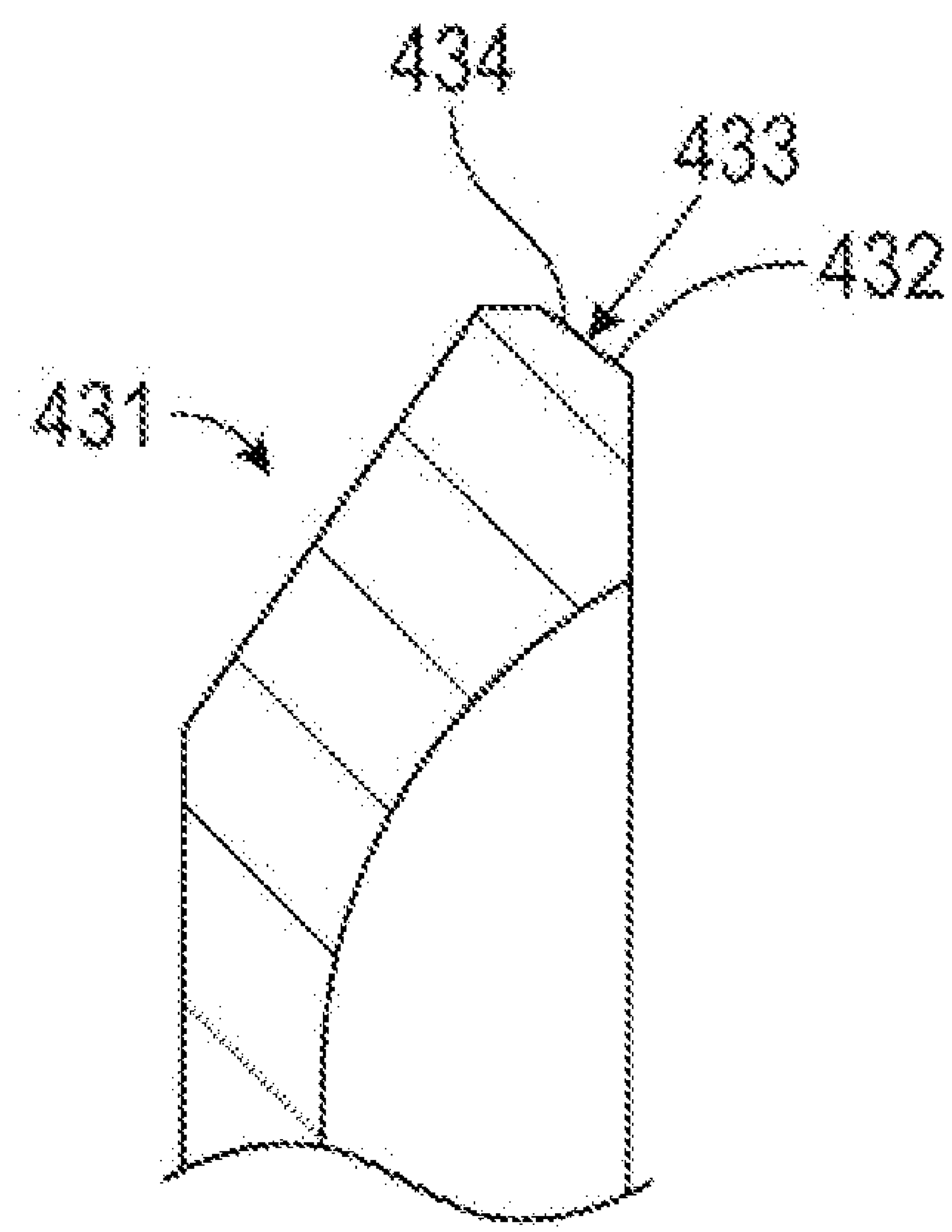
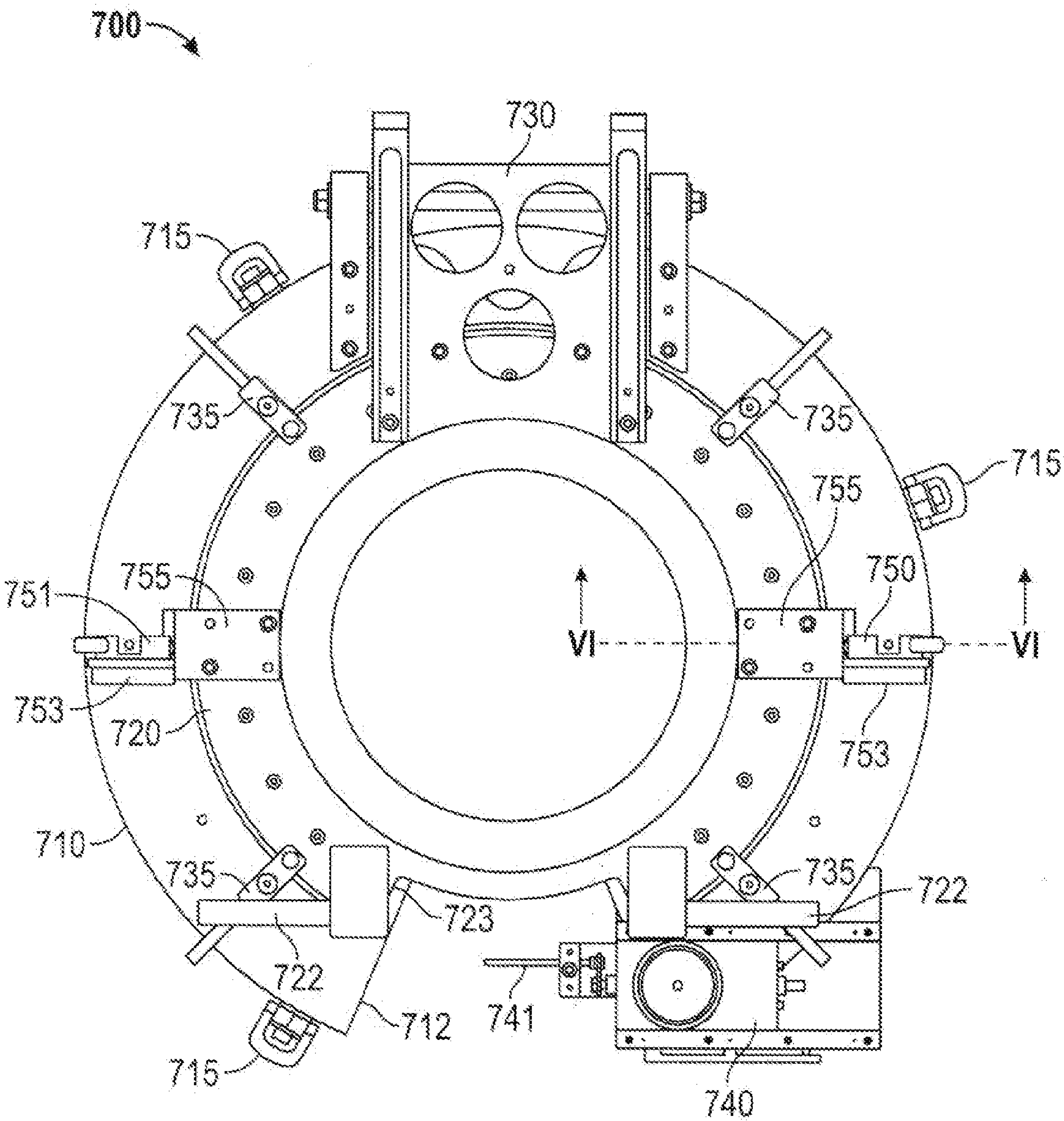


FIG. 4


700
730
715
735
735
715
755
755
750
751
VI
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753
720
753
710
735
735
722
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741
722
712
715
740

FIG. 5

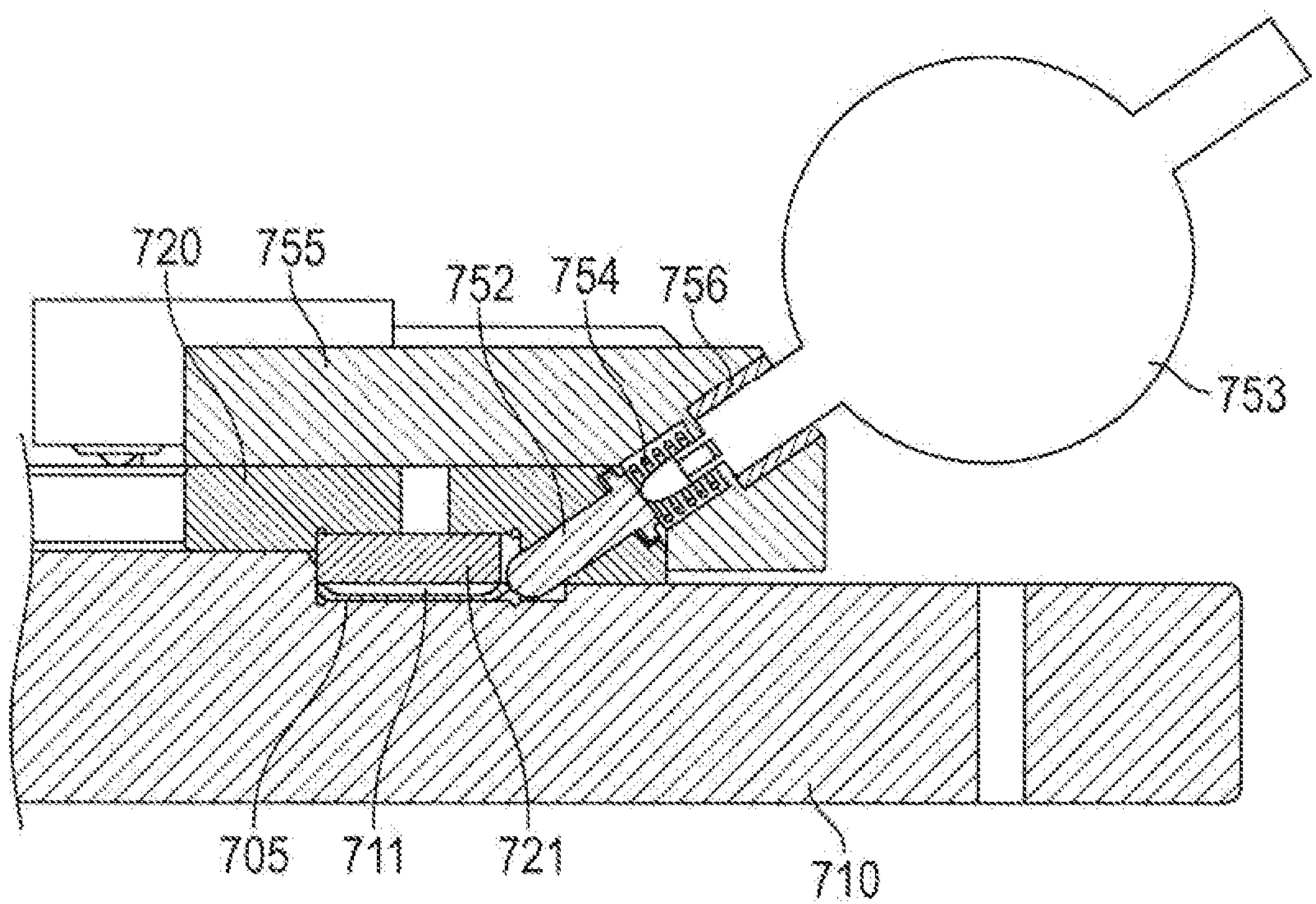

FIG. 6

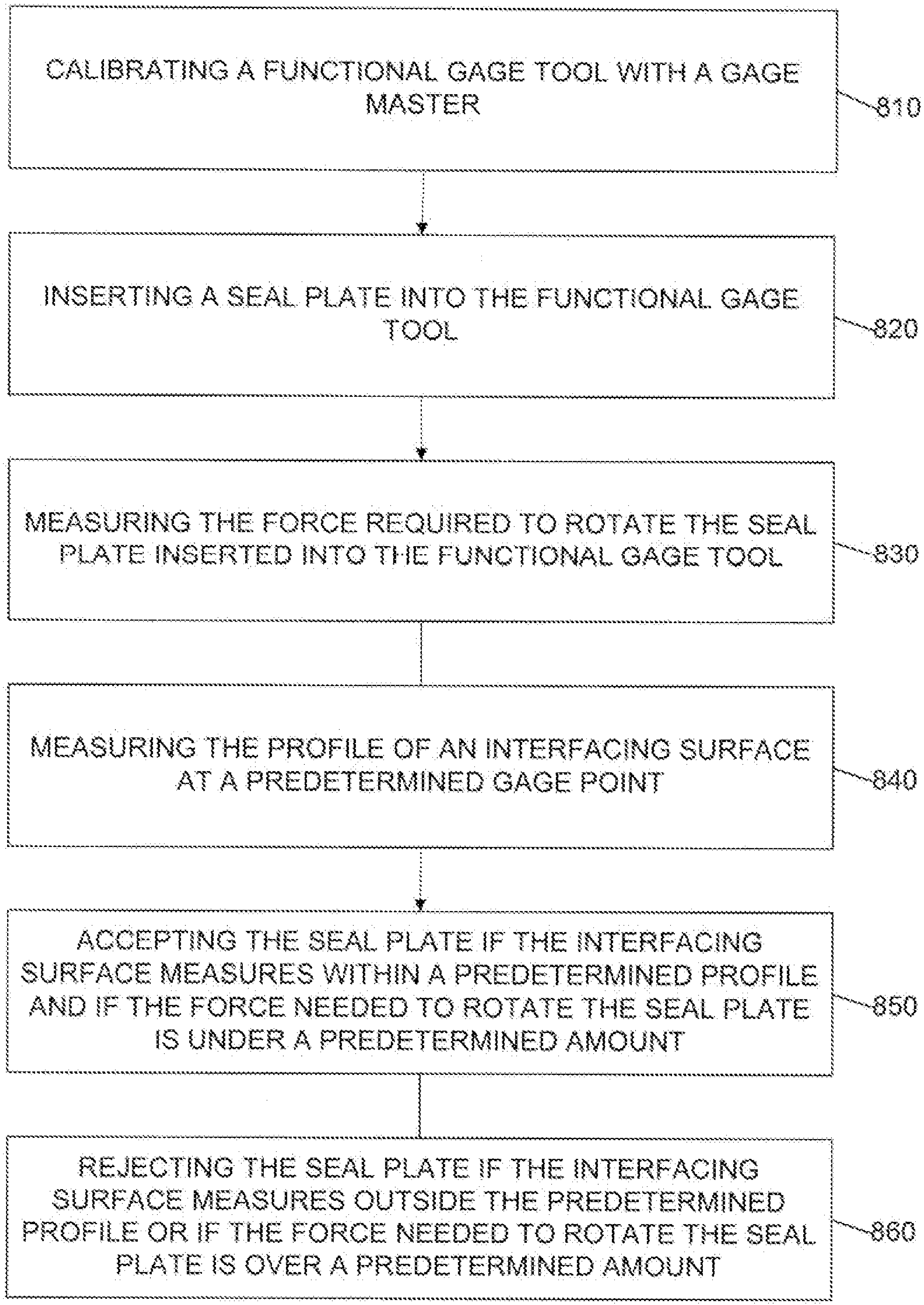
CALIBRATING A FUNCTIONAL GAGE TOOL WITH A GAGE MASTER
810
INSERTING A SEAL PLATE INTO THE FUNCTIONAL GAGE TOOL
820
MEASURING THE FORCE REQUIRED TO ROTATE THE SEAL PLATE INSERTED INTO THE FUNCTIONAL GAGE TOOL
830
MEASURING THE PROFILE OF AN INTERFACING SURFACE AT A PREDETERMINED GAGE POINT
840
ACCEPTING THE SEAL PLATE IF THE INTERFACING SURFACE MEASURES WITHIN A PREDETERMINED PROFILE AND IF THE FORCE NEEDED TO ROTATE THE SEAL PLATE IS UNDER A PREDETERMINED AMOUNT
850
REJECTING THE SEAL PLATE IF THE INTERFACING SURFACE MEASURES OUTSIDE THE PREDETERMINED PROFILE OR IF THE FORCE NEEDED TO ROTATE THE SEAL PLATE IS OVER A PREDETERMINED AMOUNT
860

FIG. 7

FREE-STATE SEAL PLATE FUNCTIONAL GAGE TOOL

TECHNICAL FIELD

The present disclosure generally pertains to gas turbine engines, and is more particularly directed toward a functional gage tool for a gas turbine engine free-state seal plate.

BACKGROUND

Gas turbine engines include compressor, combuster, and turbine sections. Certain components of a gas turbine engine may be subject to numerous tolerances. Some free-state tolerances may be difficult to determine and measure.

U.S. Pat. No. 4,491,787 to N. Akiyaroa discloses a device for measuring a flatness of a plate such as a silicon wafer, a GGG wafer, a printed circuit board, a ceramic substrate, or the like. The measuring device is provided with a disc which is disposed in parallel with the plate on one of the surfaces of the plate and is driven by a rotating drive source and a plurality of detectors for detecting a distance from the detector to the surface of the plate, the detectors being disposed on the surface closer to the disc. With this arrangement, distance data from the plurality of the detectors to the surface of the plate is obtained during the course of the rotation of the disc, and a flatness of die plate is measured.

The present disclosure is directed toward overcoming one or more of the problems discovered by the inventors.

SUMMARY OF THE DISCLOSURE

A gage tool for inspecting tolerances of a gas turbine engine seal plate is disclosed. The gage tool includes a base plate and a top plate. The base plate includes a slot with an annular shape sized to receive a seal plate. The baseplate also includes abase opening providing access to a portion of a seal plate that is placed within the gage tool. The top plate includes a top opening providing access to a portion of a seal plate that is placed within the gage tool. The gage tool also includes a first gage with a probe tip for measuring a variation in an outer interfacing surface of a seal plate. The gage tool further includes a seal slide gage for measuring a force required to rotate the seal plate within the gage tool.

A method for inspecting a gas turbine engine seal plate is also disclosed. The method includes calibrating a gage tool including a base plate with a slot and base opening, a top plate with a top opening, a first gage, a seal slide gage, and a gage master. The gage master is inserted into the slot and used to set a zero point for the first gage. The method also includes inserting a seal plate into the gage tool. The method includes measuring the force required to rotate the seal plate while the seal plate is inserted into the functional gage tool and measuring a profile of an interfacing surface at a predetermined gage point. The method also includes accepting the seal plate if the interfacing surface measures within a predetermined profile and if the force required to rotate the seal plate is under a predetermined amount. The method further includes rejecting the seal plate if the interfacing surface measures outside of the predetermined profile or if the force required to rotate the seal plate is over the predetermined amount.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic illustration of an exemplary gas turbine engine.

FIG. **2** is a cross-sectional view of a portion of a turbine of the gas turbine engine of FIG. **1**.

FIG. **3** is a cross-sectional view of the seal plate of FIG. **2**.

FIG. **4** is a view of a cross-section of the outer portion of the seal plate of FIG. **3**.

FIG. **5** is a plan view of a seal plate functional gage tool for the seal plate of FIG. **3**.

FIG. **6** is a cross-sectional view of the functional gage tool of FIG. **5**.

FIG. **7** is a flowchart of a method for inspecting a gas turbine engine seal plate.

DETAILED DESCRIPTION

The systems and methods disclosed herein include a functional gage tool for a gas turbine engine seal plate. In embodiments, the functional gage tool includes a base plats with a slot and a top plate with a ring insert. The slot and ring insert simulate the gas turbine engine disk assembly for the seal plate. In embodiments, the functional gage tool also includes a first gage and a seal slide gage. The first gage measures the profile of an outer interfacing surface on a seal plate chamfer, while the seal slide gage measures the force required to rotate the seal plate within the functional gage tool. The functional gage tool may provide a quick and accurate process to inspect the seal plate flatness and the profile of the outer interfacing surface.

FIG. **1** is a schematic illustration of an exemplary gas turbine engine. Some of the surfaces have been left out or exaggerated (here and in other figures) for clarity and ease of explanation. Also, the disclosure may reference a forward and an aft direction. Generally, all references to "forward" and "aft" are associated with the flow direction of primary air (air used in the combustion process), unless specified otherwise. For example, forward is "upstream" relative to primary air flow, and aft is "downstream" relative to primary air flow.

In addition, the disclosure may generally reference a center axis **95** of rotation of the gas turbine engine, which may be generally defined by the longitudinal axis of its shaft **120** (supported by a plurality of bearing assemblies **150**). The center axis **95** may be common to or shared with various other engine concentric components. All references to radial, axial, and circumferential directions and measures refer to center axis **95**, unless specified otherwise, and terms such as "inner" and "outer" generally indicate a lesser or greater radial distance from, wherein a radial **96** may be in any direction perpendicular and radiating outward from center axis **95**.

A gas turbine engine **100** includes an inlet **110**, a shaft **120**, a gas producer or "compressor" **200**, a combustor **300**, a turbine **400**, an exhaust **500**, and a power output coupling **600**. The gas turbine engine **100** may have a single shaft or a dual shaft configuration.

The compressor **200** includes a compressor rotor assembly **210**, compressor stationary vanes ("stators") **250**, and inlet guide vanes **255**. The compressor rotor assembly **210** mechanically couples to shaft **120**. As illustrated the compressor rotor assembly **210** is an axial flow rotor assembly. The compressor rotor assembly **230** includes one or more compressor disk assemblies **220**. Each compressor disk assembly **220** includes a compressor rotor disk that is circumferentially populated with compressor rotor blades. Stators **250** axially follow each of the compressor disk assemblies **220**. Each compressor disk assembly **220** paired with the adjacent stators **250** that follow the compressor disk assembly **220** is considered a compressor stage. Compressor **200** includes multiple compressor stages. Inlet guide vanes **255** axially precede the first compressor stage.

The combustor **300** includes one or more injectors **350** and includes one or more combustion chambers **390**.

The turbine **400** includes a turbine rotor assembly **410** and turbine nozzles **450**. The turbine rotor assembly **410** mechanically couples to the shaft **120**. As illustrated, the turbine rotor assembly **410** is an axial flow rotor assembly. The turbine rotor assembly **410** includes one or more turbine disk assemblies **420**. Each turbine disk assembly **420** includes a turbine disk **421** (shown in FIG. **2**) that is circumferentially populated with turbine blades **425** (shown in FIG. **2**). Each turbine disk assembly **420** may also include a seal plate **430** (shown in FIG. **2**). Turbine nozzles **450** axially precede each of the turbine disk assemblies **420**. Each turbine disk assembly **420** paired with the adjacent turbine nobles **450** that precede the turbine disk assembly **420** is considered a turbine stage. Turbine nozzles **450** may be supported by a diaphragm **460** (shown in FIG. **2**). Turbine **400** includes multiple turbine stages.

The exhaust **500** includes an exhaust diffuser **520** and an exhaust collector **550**.

FIG. **2** is a cross-sectional view of a portion of the turbine **400** of the gas turbine engine **100** of FIG. **1**. Referring to FIG. **2**, each turbine disk assembly **420** includes a turbine disk **421** and turbine blades **425** (only one shown in FIG. **2**). Turbine disk **421** may include a disk groove **422** in the all side of the turbine disk **421** and may also include a disk hook **423** extending from the disk groove **422**. Each turbine blade **425** includes an airfoil **426**, a blade platform **427**, and a blade root (not shown). The airfoil **426** extends radially outward from the blade platform **427** and the blade root extends in the direction opposite the airfoil **426**. Blade platform **427** may include blade hook **428**. Blade hook **428** extends from blade platform **427**. Blade hook **428** may extend in a direction towards disk hook **423** and disk hook **423** may extend in a direction towards blade hook **428**. Turbine **400** may include shrouds **419** located radially outward of and adjacent to airfoils **426**.

Each turbine rotor assembly **410** may also include a seal plate **430**. Seal plate **430** may be located axially aft of turbine disk **421** and may extend radially from blade hook **428** to disk hook **423** in the form of a disc or a ring. FIG. **3** is a view of a cross-section of the seal plate **430** of FIG. **2**. Referring now to FIG. **3**, seal plate **430** may include a central interfacing surface **435**, an outer seal plate **431**, and an inner seal plate **436**. Central interfacing surface **435** may contact the aft side of turbine disk **421** as shown in FIG. **2**. Central interfacing surface **435** may also contact the blade root of the turbine blades **425**, covering the aft interface between turbine disk **421** and turbine blades **425**.

FIG. **4** is a cross-sectional view of an outer portion of die seal plate of FIG. **3**. Referring to FIGS. **3** and **4**, outer seal plate **431** may extend away from central interfacing surface **435** and may extend away from inner seal plate **436**. Outer seal plate **431** may include chamfer **432** and outer interfacing surface **433**. Chamfer **432** may be angled to match the shape of blade hook **428**. Outer interfacing surface **433** is the surface located on chamfer **432** and may contact blade hook **428** as shown in FIG. **2**. Outer interfacing surface **433** includes chamfer gage point **434**. Chamfer gage point **434** may be a predetermined location on outer interfacing surface **433** that a gage tool contacts to measure the profile of outer interlacing surface **433**.

Referring again to FIG. **3**, inner seal plate **436** may extend away from central interfacing surface **435** and may extend away from outer seal plate **431**. Inner seal plate **436** may have an arced shape or profile and may include inner interfacing surface **437**. Inner seal plate **436** may be installed within disk groove **422** with inner interfacing surface **43** contacting disk hook **423** as shown in FIG. **2**. In one embodiment, inner interfacing surface **437** is parallel to central interfacing surface **435**.

FIG. **5** is a plan view of a functional gage tool **700** for the seal plate **430** of FIG. **3**. The functional gage tool **700** is used to inspect the seal plate **430** to ensure the seal plate **430** falls within predetermined tolerances. The functional gage tool **700** may have a clam shell design and may include a base plate **710**, a top plate **720**, and a hinge **730**. The base plate **710** may generally have a ring or a flat disc shape with a cylindrical surface. The base plate **710** may include a base opening **712** and hoist rings **715**. The base opening **712** may be a cut out, slot, or gap in the cylindrical shape of the base plate **710**. The base opening **712** may be configured to provide access to the seal plate **430** within the gage tool **700**. Hoist rings **715** may be located at the cylindrical surface. In one embodiment, the base plate **710** includes three hoist rings **715**.

The top plate **720** may be coupled to the base plate **710** by the hinge **730**. The top plate **720** may also have a ring or a disc shape. The top plate **720** may include a top opening **723** and handles **722**. The top opening **723** may align with the base opening **712** and may be a cut out, slot, or gap in the cylindrical shape of the top plate **720**. The top opening **723** may be configured to provide access to the seal plate **430** within the gage tool **700**. The base opening **712** and the top opening **723** may be located opposite the hinge **730**. The handles **722** may also be located opposite the hinge **730**, adjacent to the top opening **723**.

The functional gage tool **700** may also include clamp assemblies **735**, a first gage **750**, a second, gage **751**, and a seal slide, gage **740**. Each clamp assembly **735** may be coupled to the base plate **710**. Each clamp assembly **735** may rotate to lock or clamp the top plate **720** to the base plate **730** when the top plate **720** is in a closed position. In one embodiment, the functional gage tool **700** includes four clamp assemblies **735**.

The first gage **750** and the second gage **751** may be coupled to the top plate **720**. In the embodiment shown in FIG. **5**, the first gage **750** and the second gage **751** are approximately one-hundred and eighty degrees apart. The hinge **730** may be approximately circumferentially equidistant between the first gage **750** and the second gage **751**. The seal slide gage **740** may be located circumferentially between the first gage **750** and the second gage **751**, opposite hinge **730** and adjacent the base opening **712** and the top opening **723**. The seal slide gage **740** may be a force gage and may include a thumb ring **741**. The thumb ring **741** may be aligned with and may be situated above the base opening **12** and the top opening **723**. The seal slide gage **740** may be configured to measure the force required to rotate the seal plate **430** within the gage tool **700**.

FIG. **6** is a cross-sectional view of the functional gage tool **700** showing the first gage **750** of FIG. **5** with a gage master **705**. The first gage **750** and the second gage **751** may be the same or similar devices. The first gage **750** and the second gage **751** may include indicators. In one embodiment, the first gage **750** and the second gage **751** include dial indicators. In another embodiment, the first gage **750** and the second gage **751** include a digital indicator **753**. The description of the first gage **750** with regard to FIG. **6** may apply to the second gage **751**.

Referring now to FIG. **6**, the first gage **750** may include a probe tip **752**, a compression spring **754**, an indicator block **755**, and a bushing **756**. Probe tip **752** contacts outer interfacing surface **433** at chamfer gage point **434** when a seal plate **430** is placed within the functional gage tool **700**. Probe tip **752** may be configured to measure a variation in the profile of outer interfacing surface **433**. In the embodiment shown in

FIG. 6, a plunger with a spherical tip is used on the probe tip **752**. Other tips such as cylindrical tips or needle-shaped tips may also be used. Compression spring **754** may bias the probe tip **752** towards the seal plate **430**. Indicator block **755** may hold probe tip **752**, compression spring **754**, and digital indicator **753** in place. Indicator block **755** may couple to top plate **720**. A bushing **756** may be provided between indicator block **755** and digital indicator **753**.

Base plate **710** includes a slot **711**. Slot **711** may be an annular slot sized to receive seal plate **430**. Top plate **720** may include a ring insert **721**. Ring insert **721** may be sized with slot **711** to form an annular envelope that encapsulates seal plate **430** and simulates or is otherwise configured to simulate the space formed by turbine disk **421** and turbine blades **425** where the seal plate **430** is installed within the gas turbine engine **100**. The cross-section of the annular envelope matches or is configured to match the general cross-section formed by turbine disk **421** and a turbine blade **425** where the seal plate is installed. Ring insert **721** may be formed of a harder material than the materials used for other components of the functional gage tool **700**. The functional gage tool **700** may also include a gage master **705**. The gage master **705** may be used to set the zero point of the indicator. The gage master **705** may have the same cross-section as the seal plate **430**. In one embodiment, the gage master **705** is configured to duplicate the cross-section of a seal plate **430** in the perfect nominal condition. In another embodiment the gage master **705** is configured to duplicate the cross-section of a seal plate **430** in the maximum material condition. In yet another embodiment, the gage master **705** is configured to duplicate the cross-section of a seal plate **430** with the outer interfacing surface **433**. In the perfect nominal condition, and all other relevant surfaces including the central interfacing surface **435** and the inner interfacing surface **437** in the maximum material condition.

One or more of the above components (or their subcomponents) may be made from stainless steel and/or durable, high temperature materials known as “superalloys”. A superalloy, or high-performance alloy, is an alloy that exhibits excellent mechanical strength and creep resistance at high temperatures, good surface stability, and corrosion and oxidation resistance. Superalloys may include materials such as HASTELLOY, INCONEL, WASPALOY, RENE alloys, HAYNES alloys, INCOLOY, MP98T, TMS alloys, and CMSX single crystal alloys.

INDUSTRIAL APPLICABILITY

Gas turbine engines may be suited for any number of industrial applications such as various aspects of the oil and gas industry (including transmission, gathering, storage, withdrawal, and hitting of oil and natural gas), the power generation industry, cogeneration, aerospace, and other transportation industries.

Referring to FIG. **1**, a gas (typically air **10**) enters the inlet **110** as a “working fluid”, and is compressed by the compressor **200**. In the compressor **200**, the working fluid is compressed in an annular flow path **115** by the series of compressor disk assemblies **220**. In particular, the air **10** is compressed in numbered “stages”, the stages being associated with each compressor disk assembly **220**. For example, “4th stage air” may be associated with the 4th compressor disk assembly **220** in the downstream or “aft” direction, going from the inlet **110** towards the exhaust **500**). Likewise, each turbine disk assembly **420** may be associated with a numbered stage.

Once compressed air **10** leaves the compressor **200**, it enters the combustor **300**, where it is diffused and fuel **20** is added. Air **10** and fuel **20** are injected into the combustion chamber **390** via injector **350** and combusted. Energy is extracted front the combustion reaction via the turbine **400** by each stage of the series of turbine disk assemblies **420**. Exhaust gas **90** may then be diffused in exhaust diffuser **520**, collected and redirected. Exhaust gas **90** exits the system via an exhaust collector **550** and may be further processed (for example, to reduce harmful emissions, and/or to recover heat from the exhaust gas **90**).

A portion of compressed air **10** may exit the compressor **200** and be redirected as cooling air. Some of this cooling air may be used to cool turbine blade **425** and turbine disk **421**. Cooling air may leak aft from the interface of the interface of the turbine disk **421** and the root of the turbine blades **425**. Seal plate **430** may reduce or prevent this leakage, which may improve the gas turbine engine performance and efficiency.

To prevent leakage, the spacing of seal plate **430** with turbine disk **421** and turbine blades **425** may be relatively small. Seal plate **430** may require relatively tight tolerances to ensure proper installation of seal plate **430** and to ensure a proper seal during gas turbine engine operations. In particular, the flatness of central interfacing surface **435**, the straightness of central interfacing surface **435**, and the profile of outer interfacing surface **433** may need to be within predetermined tolerances. In one embodiment, the flatness of central interfacing surface **435** needs to be within a tolerance of 0.018 in. (0.45 mm), the straightness of central interfacing surface **435** needs to be within a tolerance of 0.008 in. (0.203 mm), and the profile of outer interfacing surface **433** needs to be within a tolerance of 0.008 in. (0.203 mm). A seal plate **430** outside of the predetermined tolerances may bind during installation, which may increase installation times, prevent proper installation of turbine blades **425**, and may increase manufacturing costs.

Seal plate **430** may have a relatively thin disk shape. The manufacturing processes such as machining and work hardening may cause internal stresses resulting in a potato chip effect or irregularities in the flatness of the disk shape. Measuring the flatness of central interfacing surface **435** and the profile of outer interfacing surface **433** may be difficult due to the relatively thin disk shape of seal plate **430**. Any object that contacts, holds, or measures seal plate **430** may bead or deflect seal plate **430** which may prevent an accurate measurement of the tolerances of seal plate **430**.

Functional gage tool **700** may be used to inspect the tolerances of seal plate **430** including the flatness and straightness of central interfacing surface **435** in a free-state, non-constrained condition, and the profile of outer interfacing surface **433** in a free-state, non-constrained condition. Functional gage tool **700** may be configured to simulate the disk assembly. Slot **711** and ring insert **721** may be constructed or configured to simulate the surfaces of turbine disk **421** and turbine blades **425** that contact outer interfacing surface **433**, central interfacing surface **435**, and inner interfacing surface **437** when seal plate **430** is installed into turbine **400**.

The simulated space created by slot **711** and ring insert **721** may not clamp down on seal plate **430**. The simulated space may allow a seal plate **430** with conforming tolerances to freely rotate within the functional gage tool **700**. A seal plane **430** may be accepted as within tolerance if the seal plate **430** freely rotates within the functional gage tool **700** or if the seal plate **430** rotates with an applied force under a predetermined amount. The applied force to rotate the seal elate **430** may be measured by the seal slide gage **740**. In the embodiment depicted in FIG. **3**, the seal plate **430** may be accessed at the base opening **712** and the top opening **723**. This type of inspection may provide for a quick and accurate inspection of the seal plate **430**. This may reduce inspection times and may improve the manufacturing process by providing more accurately controlled tolerances on each seal plate **430** inspected.

The profile of outer interfacing surface **433** may be inspected by measuring the variation in outer interfacing surface **433** at chamfer gage point **434**. First gage **750** and second gage **751** may be used to measure the variation in outer interfacing surface **433** at chamfer gage point **434**. Deflection or bending of seal plate **430** caused by the probe tips **752** of first gage **750** and second gage **751** contacting seal plate **430** may be minimized or reduced by the restricted simulated space created by slot **711** and ring insert **721**.

FIG. **7** is a flowchart of a method for inspecting a gas turbine engine seal plate such as seal plate **430**. The method includes calibrating a functional gage tool **700** with a gage master **705**; the functional gage tool **700** includes a base plate **710** with a base opening **712**, a top plate **720** with a top opening **723**, a first gage **750**, and a seal slide gage **740** at step **810**. Calibrating the functional gage tool **700** with the gage master **705** may include inserting the gage master **705** into the functional gage tool **700** and using the gage master **705** to set a zero point for the first gage **750**.

Step **810** may be followed by inserting a seal plate **430** into the functional gage tool **700** at step **820**. Step **820** may also include removing the gage master **705** prior to inserting the seal plate **430**. Step **820** may be followed by measuring the force required to rotate the seal plate **430** inserted into the functional gage tool **700** at step **830**. The force to rotate the seal plate **430** may be applied by hand or by a separate tool and may be measured by a force gage such as seal slide gage **740**. Step **820** may also be followed by measuring the profile of an interfacing surface such as outer interfacing surface **433** at a predetermined gage point such as chamfer gage point **434** at step **840**.

Steps **830** and **840** can be followed by accepting the seal plate **430** if the interfacing surface measures within a predetermined profile and if the force needed to rotate the seal plate **430** is under a predetermined amount at step **850**. Steps **830** and **840** may also be followed by rejecting the seal plate **430** if the interfacing surface measures outside the predetermined profile or if the force needed to rotate the seal plate **430** is over a predetermined amount at step **860**.

Step **860** may be followed by heat treating the seal plate **430**. Heat treating the seal plate **430** may remove or reduce internal stresses, which may remove or reduce irregularities in the flatness of seal plate **430**. Steps **810** through **860** may be repeated after heat treating the seal plate **430**.

It is understood that the steps disclosed herein (or parts thereof) may be performed in the order presented or out of the order presented, unless specified otherwise. For example, measuring the force required to rotate the seal plate **430** at step **830** may be performed prior to, after, or simultaneously to measuring the profile of an interfacing surface at step **840**.

The preceding detailed description is merely exemplary in nature and is not intended to limit the invention or the application and uses of the invention. The described embodiments are not limited to use in conjunction with a particular type of gas turbine engine and gas turbine engine tooling. Hence, although the present disclosure, for convenience of explanation, depicts and describes a particular gage tool it will be appreciated that the gage toed in accordance with this disclosure can be implemented in various other configurations, can be used with various other types of gas turbine engines, and can be used in conjunction with other types of machines. Furthermore, there is no intention to be bound by any theory presented in the preceding background or detailed description. It is also understood that the illustrations may include exaggerated dimensions to better illustrate the referenced items shown, and are not consider limiting unless expressly stated as such.

What is claimed is:

1. A gage tool for inspecting tolerances of a gas turbine engine seal plate, the gage tool comprising:
- a base plate having
  - a slot including an annular shape sized to receive a seal plate, and
  - a base opening providing access to a portion of the seal plate that is placed within the gage tool;
- a top plate having
  - a top opening providing access to a portion of the seal plate that is placed within the gage tool;
- a first gage having a probe tip for measuring a variation in an outer interfacing surface of the seal plate; and
- a seal slide gage for measuring a force required to rotate the seal plate within the gage tool.

2. The gage tool of claim **1**, wherein the gage tool further includes a second gage having a probe tip for measuring a variation in the outer interfacing surface of the seal plate.

3. The gage tool of claim **1**, wherein the top plate includes a ring insert, the ring insert being formed of a material harder than the material forming a remainder of the top plate, and wherein the ring insert forms a portion of a cross-sectional shape that encapsulates the seal plate.

4. The gage tool of claim **1**, wherein the seal slide gage is a force gage and includes a thumb ring.

5. The gage tool of claim **1**, further comprising:
- a plurality of clamp assemblies coupled to the base plate, each clamp assembly locks the top plate to the base plate into a closed position.

6. The gage tool of claim **1**, further comprising:
- a hinge coupling the top plate to the base plate; and
- a handle connected to the top plate opposite the hinge.

7. The gage tool of claim **1**, further comprising:
- a gage master for calibrating the first gage, the gage master having a cross-section of a nominal seal plate with a nominal outer interfacing surface in a perfect nominal condition, and a central interfacing surface and an inner interfacing surface in a maximum material condition.

8. The gage tool of claim **1**, further comprising:
- a gage master for calibrating the first gage, the gage master having a cross-section of a nominal seal plate in a maximum material condition.

9. The gage tool of claim **1**, wherein the probe tip is a plunger.

10. A gage tool for inspecting tolerances of a gas turbine engine seal plate, the gage tool comprising:
- a base plate having
  - a slot including an annular shape sized to receive a seal plate, and
  - a base opening in the base plate configured to provide access to a portion of the seal plate that is placed within the gage tool;
- a top plate having
  - a top opening being a cut-out in the top plate configured to provide access to a portion of the seal plate that is placed within the gage tool;
  - a ring insert including an annular shape located adjacent to the slot
- wherein the slot and the ring insert form an annular envelope and are configured to simulate an installation of the seal plate within a gas turbine engine aft of a turbine disk and turbine blades, and radially between a disk hook and

a blade hook, with a cross-sectional shape of the annular envelope configured to simulate a cross-section of the seal plate installation location;

a seal slide gage located adjacent the base opening and the top opening, the seal slide gage being a force gage configured to measure a force required to rotate the seal plate within the gage tool.

11. The gage tool of claim **10**, further comprising:

a first gage configured to measure a variation in an outer interfacing surface of the seal plate, the first gage being an indicator.

12. The gage tool of claim **11**, further comprising:

a second gage configured to measure a variation in the outer interfacing surface of the seal plate, the second gage being an indicator located opposite the first gage.

13. The gage tool of claim **11**, further comprising:

a gage master configured to calibrate the first gage, the gage master configured to duplicate the cross-section of a nominal seal plate with a nominal outer interfacing surface in a perfect nominal condition, and a central interfacing surface and an inner interfacing surface in a maximum material condition.

14. The gage tool of claim **11**, further comprising:

a gage master configured to calibrate the first gage to a predetermined zero point, the gage master having a cross-section of a nominal seal plate.

15. The gage tool of claim **10**, wherein the ring insert is formed of a material harder than a material used for other components of the top plate.

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